Spectroscopy of Scalar Mesons with the Crystal Barrel Detector

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Three new scalar mesons have been observed by the Crystal Barrel experiment at LEAR(CERN) in the analysis of high statistics/ high precision data on $\bar{p}p$ annihilation into three neutral pseudoscalars [1]. The Crystal Barrel detector allows the complete reconstruction of $\bar{p}p$ annihilations into charged as well as neutral final states. Its main components are a multiplicity trigger, a Jet Drift Chamber (furnished by the Berkeley group) and a CsI(Tl) calorimeter.

These new results led to a major revision of our understanding of the $J^{PC} = 0^{++}$ scalar meson sector [2]. An alternative model for the classification of scalar states is discussed where the new scalars $f_0(1370)$, $a_0(1450)$ replace the well established states $f_0(980)$ and $a_0(980)$ as members of the $J^{PC} = 0^{++}$ ground state nonet. The $f_0(1500)$ is supernumerary in all classification schemes and difficult to interpret as a $q\bar{q}$ state.

This experimental progress is of particular relevance in the search for exotic meson resonances containing constituent gluons g (in particular gg states called glueballs) which are suggested by the strong gluon self coupling in QCD. The discovery of gluonic mesons would directly demonstrate the unique features of strong QCD. During the last years large scale lattice QCD calculations succeeded in quantitative predictions for glueball masses and even provide some guidance on their properties. They firmly predict the ground state glueball as an isoscalar, scalar object in the 1.5–1.8 GeV mass region.

Several papers and arguments appeared recently which identify the new state $f_0(1500)$ as a promising candidate for this long–sought scalar glueball. However, another contender, the $f_J(1710)$, is hotly debated as well. More information about decay couplings and production reactions of these states are needed for definite conclusions.

Our recent work focussed on establishing the properties of the $f_0(1500)$ using both new data (higher statistics and new channels) as well as coupled channel analyses of several related data sets. We obtain a mass and width of $m = (1505 \pm 10)$ MeV and $\Gamma = (135 \pm 15)$ MeV and the following invariant couplings to the different pseudoscalar states relative to $\pi\pi$:

$\eta\eta$	$K\bar{K}$	$\eta\eta'$
0.27 ± 0.11	$0.24 \pm 0.10\ ^{+0.13}_{-0.05}$	0.19 ± 0.08

The decay into 4π is found to be the dominant decay mode of the $f_0(1500)$, being (3.4 ± 0.8) times more frequent than 2π decays [3].

In order to further clarify the quark-gluon content of these new scalar mesons, it is essential to systematically study their $K\ \bar{K}$ coupling with similar precision as their coupling to $\pi^{\ 0}$ and η. For that purpose the Crystal Barrel detector was upgraded with a new silicon vertex detector with allows a highly selective trigger on K_S decays.

With this method we were able to increase the world statistics on K_S channels in liquid/gaseous hydrogen and in liquid deuterium by 1-2 orders of magnitude [4]. The key information for $K\ \bar{K}$ decays of intermediate scalar resonances is contained in the $K\bar{K}\pi$ final states, where we expect $(2-5) \times 10^4$ events (depending on reaction) in the final Dalitz Plots. These data are currently being analyzed in Berkeley.

Footnotes and References

[1] C. Amsler et al., (CBAR–Coll.), Phys. Lett. B355 (1995) 425, and references given there.

[2] c.f. Review of Particle Physics, R.M. Barnett et al., Phys. Rev. D 54 (1996) 1.

[3] A. Abele et al. (CBAR–Coll.), Phys. Lett. B380,(1996) 453.

[4] P. Kammel et al., (CBAR–Coll.), PANIC 96, Williamsburg, 1996.